SCEC Progress Report for 2012 SCEC funding to support paleoseismic and slip distribution research along the northern San Jacinto fault zone.

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Summary of Major Research Findings

Over the past year we have made progress in understanding the northern San Jacinto fault zone and the San Bernardino section of the San Andrea fault zone through paleoseismic trenching, mapping and measuring offset features, and dating elevated terraces. The main research findings are summarized below.

1. Deeper trenching (down to 4m depth) at the Mystic Lake paleoseismic site during the past year has resulted in the identification of 5 additional events. We now have a record of 11 events in the past 1800 years. This event history is based on 40 radiocarbon dates and all events have been observed in multiple exposures.

2. Using LiDAR and field mapping along the northern San Jacinto fault zone between Moreno Valley and Loma Linda one graduate student has identified 56 offset or deflected features (mainly streams) which have been evaluated and measured. 10 of these streams are inferred to be due to the most recent event and have an average displacement of 3.94m, which is consistent with the slip per event measurements we made by dating and measuring offset features at the Quincy site during previous years.

3. Using LiDAR and field mapping along the San Andreas fault zone in the San Bernardino area, one graduate student has identified 331 tectonogeomorphic features. 22 offset or deflected streams were measured, most of which range from 1.6 m to 60 m with four larger outliers in the 100m to 200m range. There is a slight trend in the data showing a decrease in offset amount northward through the San Bernardino area.

4. A third graduate student has collected 14 OSL samples from 7 elevated terraces deposits from the San Timoteo Badlands that have been lifted along the northern San Jacinto fault zone. The samples have been prepped and are being run at the OSL lab at CSULB. We hope to use this data to constrain the amount of vertical displacement along the fault to supplement our slip rate and paeloseismic data in this area. This student was not funded by SCEC, but the work is related.

Technical Report

For 2012, we received SCEC funding to map, describe, and measure offset features along the northern San Jacinto fault zone and the San Andreas fault in the San Bernardino area. The purpose of this work was to evaluate fault zone morphology and slip distribution to complement our recent slip rate, slip per event, and slip history data from the northern San Jacinto fault zone. By mapping the distribution of offset along the two faults, we hope to identify a geomorphic record of the last several earthquakes and possibly use this data to correlate events between paleoseismic sites. We also continued our work at the Mystic Lake paleoseismic site along the Claremont segment of the northern San Jacinto fault zone (Figure 1). Although the paleoseismic work was funded by a USGS EHP grant, it is part of ongoing SCEC research (and was supported by SCEC in previous years) and is reported here.

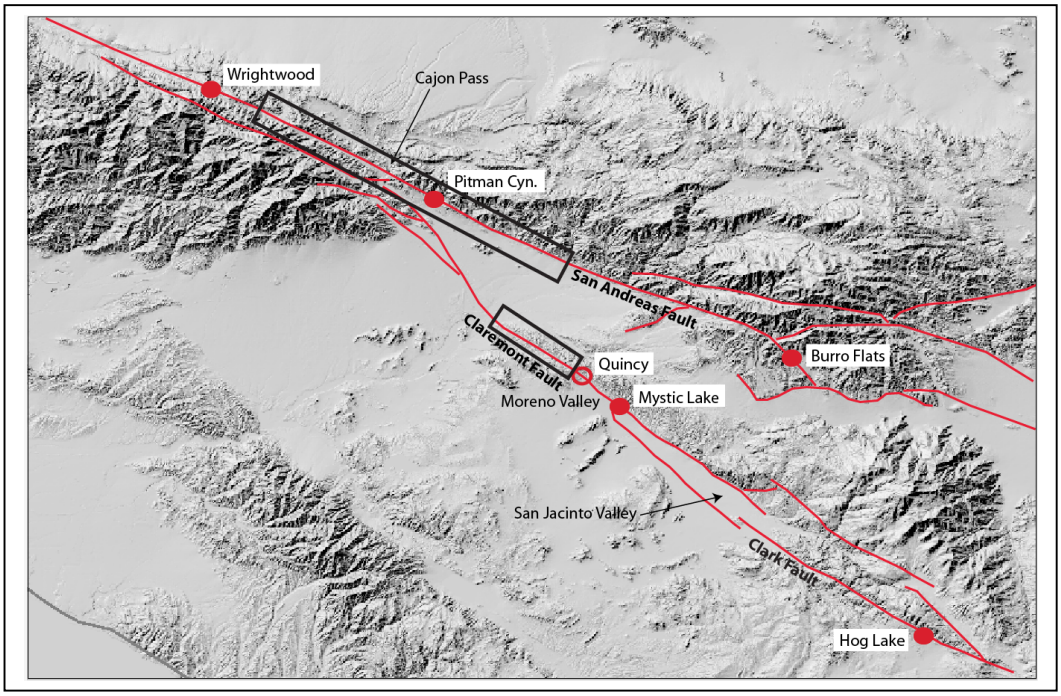

Figure 1. *Location map showing the San Andreas and San Jacinto fault zones (red lines), paleosiesmic sites (red dots), and areas of LiDAR and field-based fault zone mapping (black rectangles).*

Mystic Lake work:

Previous years of SCEC funding (2009 to 2010) enabled us to conduct mapping, CPT analysis, and shallow trenching (2m deep) at this site that resulted in a record of 7 earthquake events in the past 1600 years. We then extended the record back in time by trenching deeper in June and July of 2012 (using the first year of our USGS/EHP grant). Our most recent trench (T8) was excavated to a depth of 4 meters and exposed 5 previously undocumented older events between 200 AD and 800 AD. We now have evidence for a total of 11 events in the past 1800 years based on 40 radiocarbon dates (Figure 2). The recurrence interval ranges from 160 to 210 years, with the most recent event occurring around 1800 AD. We will excavate an additional trench this summer with Year 2 USGS funding to confirm the previously documented events, refine the dating, and extend the record farther back in time with deeper exposures. A manuscript

that deals with the ongoing Mystic Lake paleoseismic work was submitted in 2012 and published in BSSA in February of 2013. The SCEC contribution number is 1503.

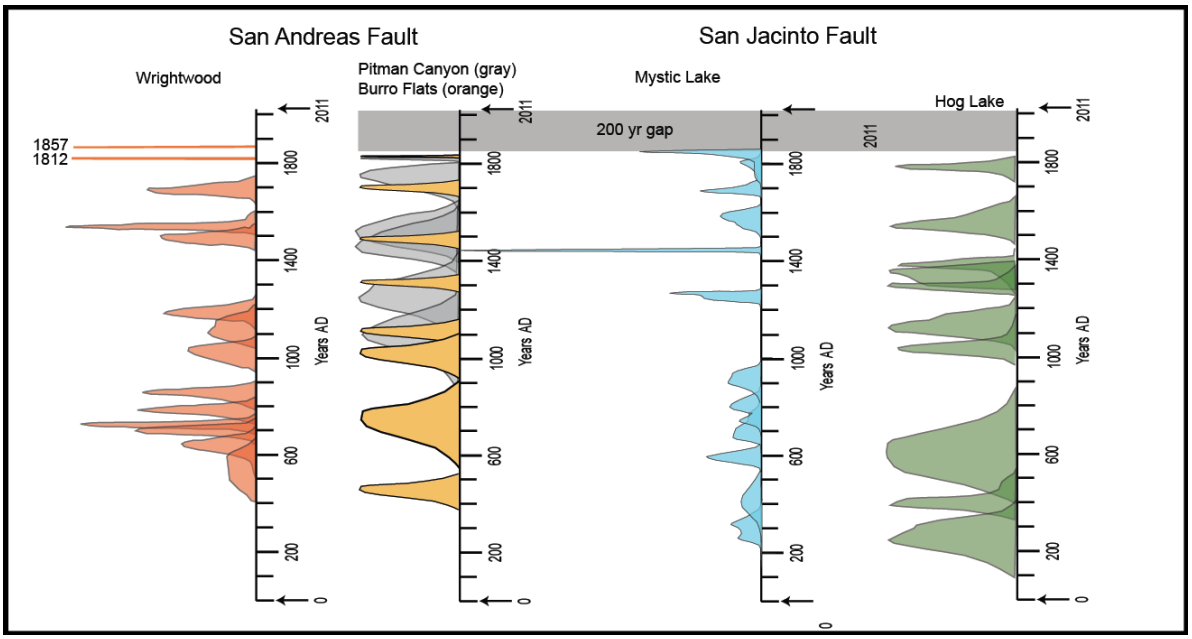

Figure 2. *Comparison of the event histories from Mystic Lake with the Wrightwood (Fumal et al., 2002), Pitman Canyon (Seitz et al., 1997), Burro Flats (Yule, 2010), and Hog Lake (Rockwell, 2008) paleoseismic sites for the last 1600 years. See Figure 2 for site locations.*

Fault zone mapping along the San Jacinto and San Andreas:
LiDAR and field mapping along the northern San Jacinto fault was done along a 12 km stretch of the fault north of our Quincy site (Figure 2). This work was done to identify, map, measure, and catalog all offset or deflected features with the intent to map out the extent and slip distribution of the most recent events identified at the Quincy and Mystic Lake sites. The smallest identified offsets were about 3 meters, with 8 features between 3 to 4 meters, which was the calculated average slip per event from the Quincy site (based on dating of one deflected stream offset in the last three events, and one buried channel offset in the last two events). Data analysis is ongoing and we cannot make confident interpretations regarding the slip distribution of the last one or two events at this time. This work constitutes the majority of one CSULB student's masters thesis and is still in progress.

LiDAR and field mapping was also conducted by a second CSULB masters student along the San Bernardino strand of the San Andreas fault between Highway 330 in the southeast to Wrightwood in the northwest (Figure 2). More than 300 tectonogeomorphic features were mapped along multiple strands of the fault zone, but of these only 22 offsets were rated "fair" to "excellent" along the inferred principle strand of the fault zone. Most of these offsets are between 10 and 40 m, suggesting that they were most likely offset in multiple events and that the most recent event cannot be isolated in this

dataset. A large jump in the offset amounts occurs about 25 km northwest of Highway 330 (Figure 3) and is being investigated further. This jump is most likely reflecting a lack of smaller drainages and a change in the topography in the area of the Cajon Pass, but may also be recording some change in the fault slip history possibly influenced by the convergence with the northern end of the San Jacinto fault at this location.

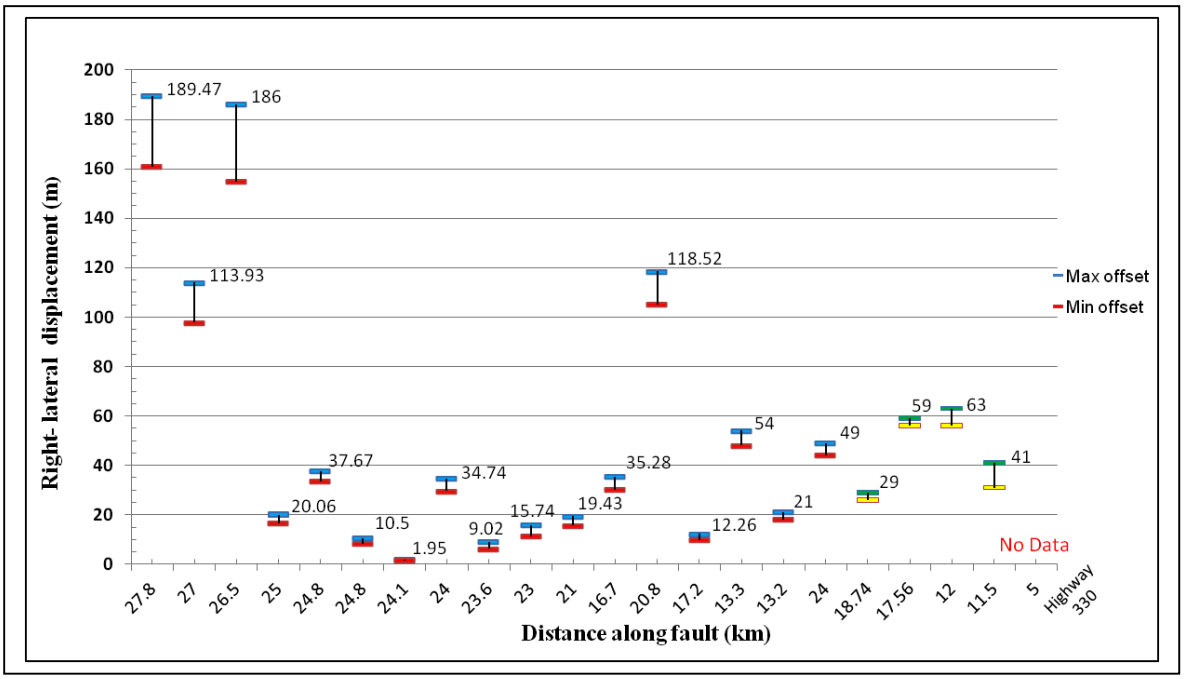

Figure 3. *Measured offsets along the San Bernardino strand of the San Andreas fault between Highway 330 and the Cajon Pass. Distances are measured northwest from Highway 330.*

References Cited:

Fumal, T., Weldon, R., Biasi, G., Dawson, T., Seits, G., Frost, W., and Schwarz, D., 2002. Evidence for large earthquakes on the San Andreas Fault at the Wrightwood, California, Paleoseismic site: A.D. 500 to Present. Bulletin of the Seismological Society of America. 92(7), 2726-2760.

Rockwell, T.K., 2008, Observations of Mode-Switching From Long Paleoseismic Records of Earthquakes on the San Jacinto and San Andreas Faults: Implications for Making Hazard Estimates From Short Paleoseismic Records. International Geologic Congress, Oslo, Norway

Seitz, G., R. Weldon, and G. Biasi, 1997. The Pitman Canyon paleoseismic record: A re-evaluation of the southern San Andreas fault segmentation. J. Geodyn. v. 24, 129-138

Yule, J. D., 2010. Personal Communication regarding the paleoseismic record at the Burro Flats site.

Outreach/SCEC Activity

-Onderdonk participated in a SCEC trench review of the Elsinore Fault (Rockwell and Ackiz) on Sept. 5th 2012

-Onderdonk and Kenyon (grad student) participated in the SCEC workshop on evaluation of measurement methods of offset features along the San Andreas fault on September 9 and 10, 2012

-Onderdonk presented results from Mystic Lake at the South Coast Geological Society poster session on Dec. 12th 2012

-Onderdonk presented results from Mystic Lake at a campus Research Symposium at CSULB on March 1, 2013

Bibliography for 2012/2013

Publications

Onderdonk, N.W., T.K. Rockwell, S. F., McGill, and G. I. Marliyani (2013). Evidence for seven surface ruptures in the past 1600 years on the Claremont fault at Mystic Lake, northern San Jacinto fault zone, California, *Bull. Seismol. Soc. Am*. **103**, no. 1, 519-541

Marliyani, G. I., T. K. Rockwell, N. W. Onderdonk, and S. F. McGill (2013). Straightening of the northern San Jacinto Fault, California as seen in the fault-structure evolution of the San Jacinto Valley stepover. *Bull. Seismol. Soc. Am*. **103**, no. 3. doi: 10.1785/0120120232